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TEMPERATURE NOISE MEASUREMENTS IN BLOCKED AND UNBLOCKED 19-PIN ELECTRICALLY HEATED LMFBR FUEL SUBASSEMBLY MOCKUPS*

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Introduction

Sodium temperature noise was measured at the exit of a simulated fast reactor fuel subassembly to determine the feasibility of using temperature noise monitors to detect flow blockages in fast reactors, a matter of ever-increasing concern in the LMFBR program. Noise from both blocked and unblocked test bundles was characterized using various noise signal descriptors such as power spectral density, cross spectral density, amplitude probability distribution, and root mean square (rms).

Investigations by Others

Bentley[1] suggested that small, slowly occurring blockages might be detected by measurement of coolant outlet temperature fluctuations (noise) due to turbulence. He investigated this hypothesis in a mockup of a sodium-cooled fuel element with electrically heated simulated fuel clusters.[2] In this reference, he proposed a simple theory of how the coolant mixing process causes temperature noise.

Mika et al. observed that coolant temperature fluctuations depended on the sodium flow rate and heat flux, and from this observation they concluded that temperature noise monitoring might be useful for detecting anomalous reactor behavior during power reactor operations.[3]

Investigations at ORNL

These referenced investigations used unblocked bundles. We extended these studies by measuring outlet sodium temperature noise at the Failed

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Fuel Mockup (FFM) with and without blockages in the test bundle. The FFM is a 19-pin, electrically heated mockup used to simulate the wire-wrapped fuel pins in a portion of a fuel subassembly for a liquid-metal fast breeder reactor. To block the flow of sodium coolant, a 1/8-in.-thick plate was placed 4 in. downstream from the start of the heated zone (total heated length was 18 in.). Approximately one-third of the total bundle cross-sectional flow area was blocked. Sodium temperature noise was measured in the center of flow channels across the bundle exit by 11 stainless steel sheathed, grounded junction, Chromel-Alumel thermocouples. Measurements were made for flow velocities in the range from 2.7 to 7.2 m/sec and for heat fluxes of 71 and 85 W/cm^2. Thermocouple analog signals were recorded on magnetic tape and were analyzed to determine power spectra and rms noise levels within the bandpass of the thermocouple (0-1 Hz) using a fast Fourier transform digital frequency analysis program.

Results

Figure 1 compares the temperature noise at the exit of blocked and unblocked bundles as a function of flow. The flow dependence and absolute noise level measured for our unblocked bundle agree quite well with earlier observations by Mika et al. However, when the bundle was partially blocked, the exit temperature noise increased a factor of 2 to 3 at each of the flow rates for which measurements were made.

Conclusions

These results indicate that it might be possible to detect blockages in LMFBRs by monitoring the noise from subassembly exit thermocouples. However, before this method can be applied to reactors with confidence, further investigations must be made to determine (1) the change in blockage detection sensitivity with varying thermocouple separation from the subassembly exit, (2) the effect of thermocouple time response on the ability to detect blockages, and (3) the sensitivity of temperature noise to changes in normal reactor operating conditions (fuel burnup or

core flux shape). In future FFM experiments, we will attempt to answer these questions.

References

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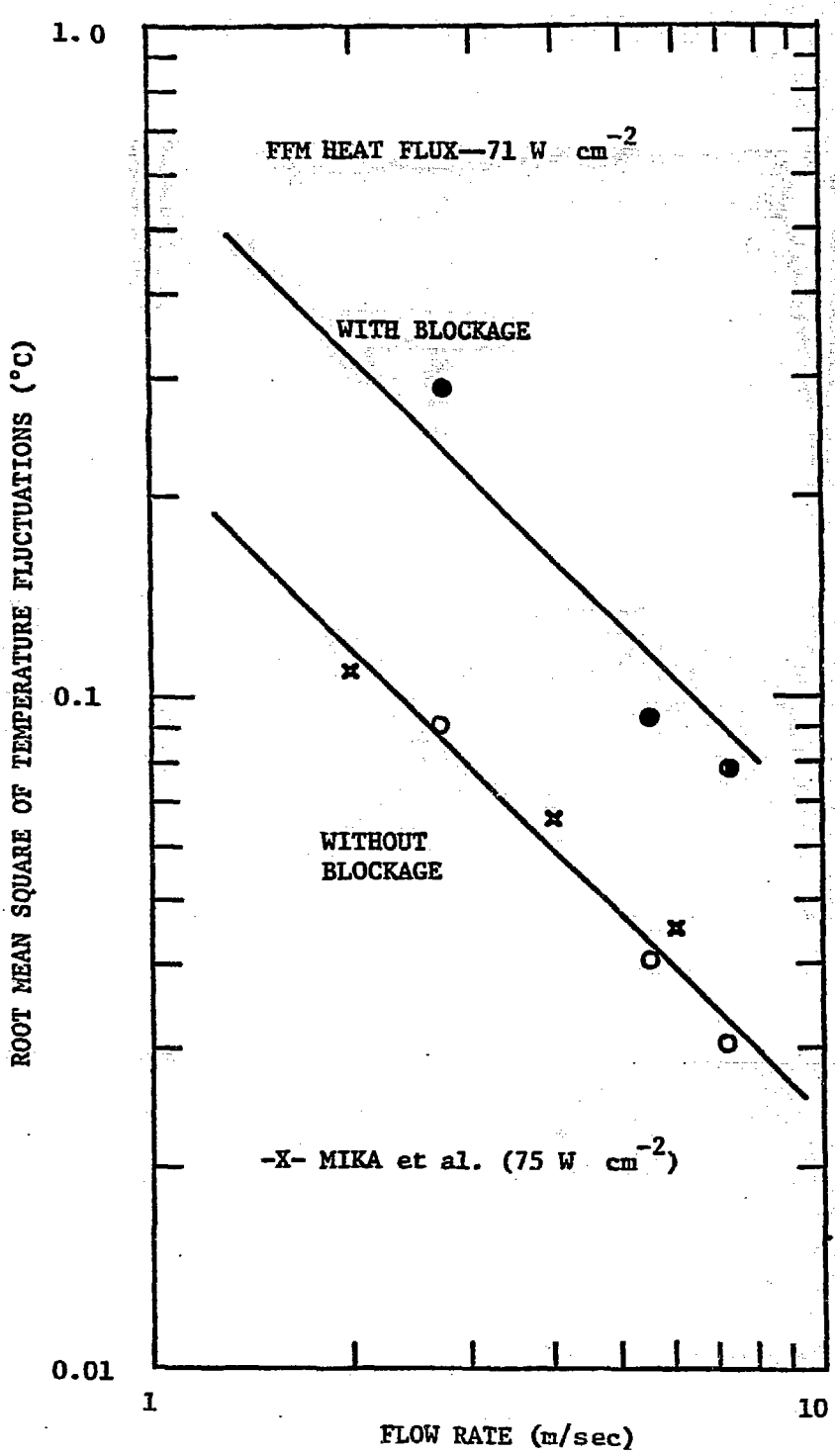

Fig. 1. Sodium temperature noise at the exit of blocked and unblocked test bundles in the Failed Fuel Mockup.